

Comment on : “Polar plumes and fine-scale coronal structures — On the interpretation of coronal radio sounding data” by Pätzold and Bird

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Radio occultation measurements, which probe electron density over a wide dynamic range with high sensitivity and high spatial and temporal resolution, reveal a solar corona permeated by a hierarchy of filamentary structures [Woo 1996a, b]. In the inner corona, the largest of these are the polar plumes, also known as polar rays, which have long been observed during solar eclipses [see e.g., Abbot, 1900]. In the outer corona, where the broad coronal streamers have narrowed to stalks beyond a few solar radii, radio occultation observations show that plumes are not confined to polar regions. Extending to distances as large as $30 R_{\odot}$, they are observed to originate from low-latitude coronal holes [Woo 1996c], as well as from the sources of coronal streamers [Woo and Habbal 1997].

The above-mentioned paper by Pätzold and Bird takes issue with the identification of plumes in the ranging or time delay measurements of path-integrated density carried out during the 1995 Ulysses solar conjunction [Woo and Habbal 1997]. The criticism is based on two premises: (1) that electron density profiles deduced from the Ulysses ranging measurements using model calculations are inconsistent with those of plumes, and (2) that the observed ranging variations interpreted as plume structure are caused by a measurement bias at one of the three ground stations. The purpose here is to show that these arguments have no merit.

Since both white-light and ranging observe path-integrated density, plumes are most naturally investigated with the measurement of path-integrated density itself, rather than with an inferred electron density. Detection of plumes in ranging measurements [Woo 1996c, Woo and Habbal 1997] has been made by noting the similarity of their path-integrated density profiles to those of white-light (e.g., properties such as angular distribution, size of plumes and peak-to-peak variations).

Pätzold and Bird have chosen to confuse the issue of plume detection in ranging measurements by carrying out a futile exercise of inferring electron density. Not only are the inferred densities highly uncertain because of their dependence on modelling, there are no in situ density measurements of plumes near the Sun to compare them with. As an example of the complication of modelling, there is no agreement even on the fundamental issue of whether plumes represent isolated flux tubes or folds in neutral sheets above polarity inversions [Marsch 1997]. The lack of direct measurements, and a poor understanding of the distribution of electron density, are also reasons for refuting the conclusions reached by Pätzold et al. [1997] on the low-latitude plumes detected in the 1991 Ulysses ranging measurements [Woo 1996c].

In attempting to show that a bias in the ranging measurements at one of the ground stations (DSS 61) accounts for the signatures attributed by Woo and Habbal [1997] to plumes, Pätzold and Bird distorted the results by showing in the above-mentioned paper the measurements of only three of the five suggested plumes. More importantly, their analysis is based on the noisier 5-min measurements, rather than the smoothed 30-min data in Woo and Habbal [1997].

Reproduced in Figure 1 are the original 30-min data of Figure 2 in Woo and Habbal [1997] covering the period DOY 55–63 during which the five suggested plumes were observed. As in the original paper, the plumes are numbered 1–5, but the data have been color coded to identify the individual ground stations. Although there are some data gaps, there is continuity in the variation of ranging even across station changes. This is

especially clear in the adjacent but similarly valued ranging measurements of DSS 42 and DSS 61 in the cases of the plumes numbered 5 and 4. There is no obvious systematic bias in the measurements of DSS 61. In the case of the 5-min data used by Pätzold and in the above-mentioned paper, the station-to-station continuity is apparently obscured by the estimation error noise.

Latitudinal profiles of polarization brightness observed by the Mauna Loa K-coronameter during the period covering the Ulysses ranging measurements have recently been obtained from J. Burkepile of HAO. Typically, these show a peak-to-peak variation of about $\pm 10\%$ across the polar plumes at $1.25 R_o$, consistent with that observed at higher altitudes in the Spartan 201-01 white-light measurements [Fisher and Guhathakurta 1995], and consistent with the variations of both 1995 (shown in Figure 1) and 1991 [Woo 1996c] Ulysses ranging measurements of plumes. This similarity reinforces the plume interpretation of the ranging measurements in Figure 1.

In conclusion, arguments against the detection of plumes in the 1995 Ulysses ranging measurements presented in the above-mentioned paper are misleading and incorrect. With the significant improvements in sensitivity and dynamic range of SOHO's white-light coronagraph measurements (LASCO) [Brueckner 1995], plumes have now been imaged beyond $10 R_o$, thus providing further support for the findings of Woo and Habbal [1997] based on ranging measurements.

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FIGURE CAPTIONS

Figure 1. Time history of 30-min ranging in terms of hexems (10^{16} electrons/m²) measured by Ulysses and normalized to 25 Ro. Time history is shown in reverse time order, corresponding to solar longitude increasing from left to right. The numbers refer to the five suggested plumes in [Woo and Habbal 1997]. The data are color coded according to ground station.

